Optimization in civil engineering

Japan’s Smart cities – Tsunami Resilient Construction

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Part 1: Japan's Smart Cities

Introduction: Justification of the choice "Japan's Smart cities "

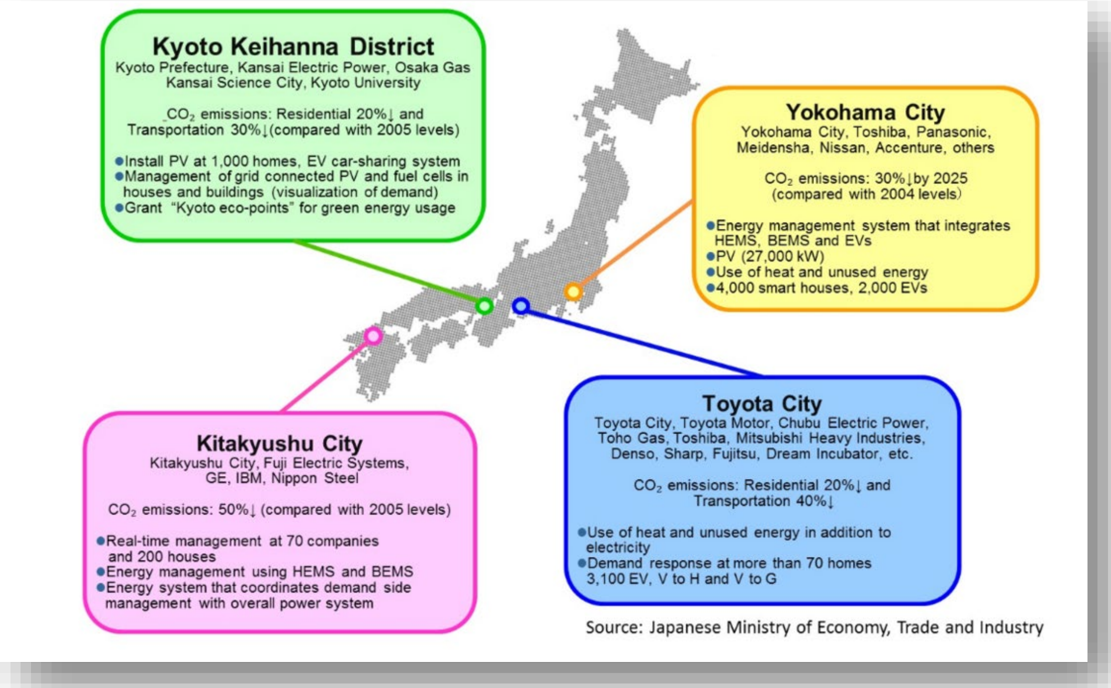
Over the years technology has given us an impressive array of advancements and improvements. One of the most remarkable and most impactful works is the Smart City, which brings so many beneficial changes to our lives. The driving force behind Smart Cities transformations is to engage people in creating a better quality of life.

Firstly, a smart city is an urban area that uses different types of electronic methods and sensors to collect **data**. Insights gained from that data are used to manage assets, resources and services efficiently; in return, that data is used to improve the operations across the city. This includes data collected from citizens, devices, buildings and assets that is then processed and analysed to monitor and manage traffic and transportation systems, power plants, utilities, water supply networks, waste, crime detection, information systems, schools, libraries, hospitals, and other community services.

So, the importance of smart cities is **to optimize** the efficiency of city operations and services and connect to citizens and those, **offer a better life condition** while respecting the principles of sustainable development.

JAPAN, a leading country in the field of smart cities.

In April 2010, the government selected specifically four regions as a large-scale demonstrator to build a smart city: the large metropolis **Yokohama**, the provincial city **Toyota**, the new and scientific city **Keihanna** Science City (prefecture of Kyoto) and the industrial city of **Kitakyushu**


Kyoto Keihanna District
Kyoto Prefecture, Kansai Electric Power, Osaka Gas
Kansai Science City, Kyoto University
CO₂ emissions: Residential 20%↓ and Transportation 30%↓(compared with 2005 levels)
●Install PV at 1,000 homes, EV car-sharing system
●Management of grid connected PV and fuel cells in houses and buildings (visualization of demand)
●Grant "Kyoto eco-points" for green energy usage
Yokohama City
Yokohama City, Toshiba, Panasonic, Meidensha, Nissan, Accenture, others
CO₂ emissions: 30%↓by 2025 (compared with 2004 levels)
●Energy management system that integrates HEMS, BEMS and EVs
●PV (27,000 kW)
●Use of heat and unused energy
●4,000 smart houses, 2,000 EVs
Kitakyushu City
Kitakyushu City, Fuji Electric Systems, GE, IBM, Nippon Steel
CO₂ emissions: 50%↓ (compared with 2005 levels)
●Real-time management at 70 companies and 200 houses
●Energy management using HEMS and BEMS
●Energy system that coordinates demand side management with overall power system
Toyota City
Toyota City, Toyota Motor, Chubu Electric Power, Toho Gas, Toshiba, Mitsubishi Heavy Industries, Denso, Sharp, Fujitsu, Dream Incubator, etc.
CO₂ emissions: Residential 20%↓ and Transportation 40%↓
●Use of heat and unused energy in addition to electricity
●Demand response at more than 70 homes
3,100 EV, V to H and V to G

Source: Japanese Ministry of Economy, Trade and Industry

Want to know better?

How does this optimize our life conditions?

It's 6 a.m. and your connected alarm clock is gradually bathing your bedroom in a blue light simulating sunrise, accompanied by soft music to gently wake you up. Now is the time to get ready for work. You squint when the curtains open automatically, because your smart home senses the activated alarm. Your smartphone is tweeting. This is an SMS from your connected coffee maker, telling you that your coffee is ready. A notification from your toaster oven app shows you live images of your toasting bagel. All of this happens before you even get out of bed. A mirror in front of you which announces your state of health, your temperature and heart beats.

After breakfast, you are ready to leave the house. You check the public transport app on your smartphone, because you will be taking the bus today. It indicates that the autonomous shuttle is 1 km away, giving you a few more minutes to enjoy your coffee. Leaving the house, you arrive at the bus stop a little early. In the meantime, you browse the digital kiosk to find the show schedule and book two movie tickets for Friday night. As you log in, the kiosk recognizes you and knows that you enjoy discovering new cuisines. He therefore recommends a few restaurants near the cinema corresponding to your adventurous palate and your consumption habits. You make a reservation for this famous Ethiopian restaurant that you were planning to try one day. And there you have it, your weekend is organized.

Your electric bus arrives on time. The doors swish open, and as you go upstairs, the shuttle's sensors detect your electronic city card in your smartphone and automatically subtract the price of the ticket. It is a virtual card that you also use to pay for many municipal services besides transport, such as your water and electricity bills, motorway tolls and even your local taxes.

Tomorrow you will have to drive to work because you have an appointment with an offsite customer. It's been a year since you run out of a car because you like using the city's electric car sharing program, picking up a car from a designated station and returning it to any station, just like you would with a bicycle. The improved mobile traffic app you downloaded is linked to city surveillance cameras and sensors that monitor the flow of traffic in real time; it notifies you of accidents and other delays and offers you a detour. Using predictive analytics, the city also uses this data to predict traffic jams.

Back home after a busy day, you approach your door which automatically unlocks when you recognize you. You anticipate a quiet evening and think about the possibilities for dinner. Instead of rummaging through your fridge wondering about the freshness of its contents, you launch the fridge app on your smartphone. It has a snapshot of what's in it and keeps track of how long the foods it contains.

it is time to go to bed. But the blouse you want to wear tomorrow for your customer interview is stained. So you decide to make a machine, and you can leave it. The connected washer and dryer has laundry folding functionality. After washing and drying your clothes, the folding feature uses image recognition to sort the clothes (blouses, pants, something else) and deploys a robot to fold them. At 10 p.m. you go to bed, knowing you'll be able to wear a freshly laundered and folded blouse.

“It’s the optimal quality of life you enjoy every day in a smart city designed by civil engineers and architects “

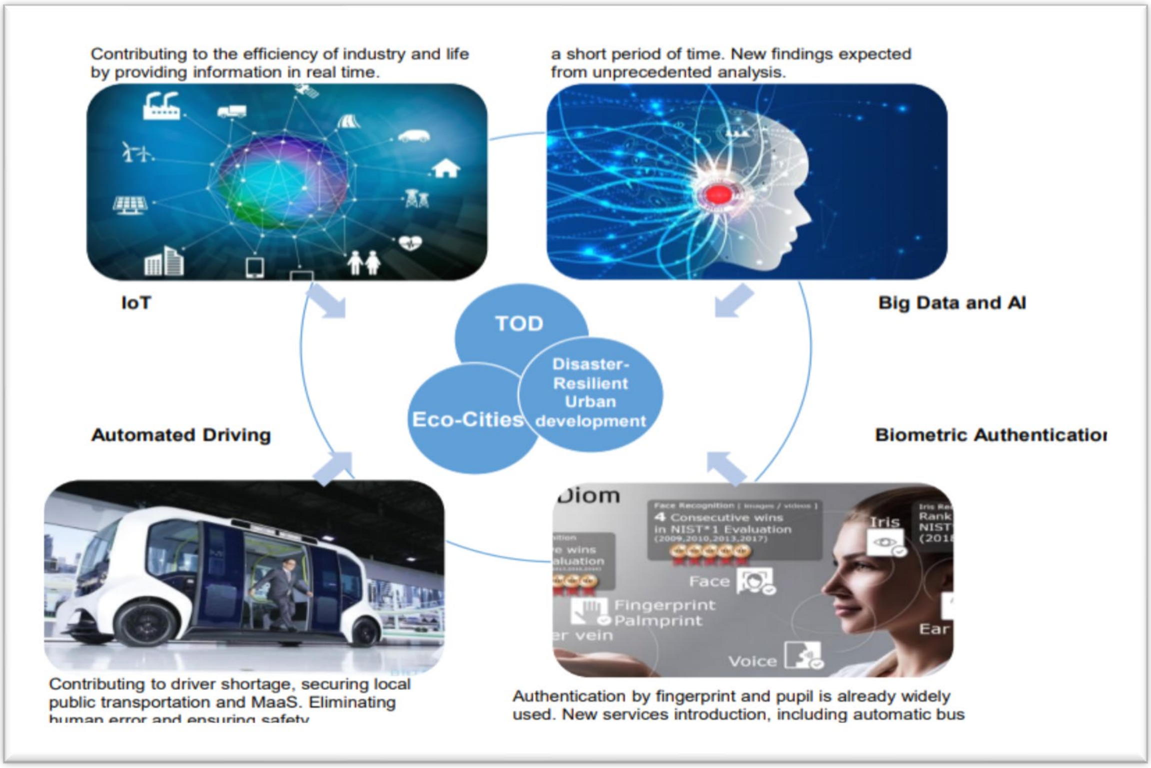
Basic pillars of the Smart City

Japan’s smart cities are based basically on the Three Pillars strategic approaches:

① Eco-Cities (Environmentally Symbiotic Cities): Thoroughly considering low carbon, resource recycling, and reduction of environmental burden

② TOD (Transit-Oriented Development): Reducing traffic congestion and upgrading urban functions through urban development with a focus on public transportation

③ Building Disaster-Resilient Cities (Resilient Cities): From now on, Japan will move forward to building a human-centered society (“Society 5.0”) that achieves both the resolution of social issues and economic development by adding Digital Transformation to the strength of conventional urban infrastructure development.


Contributing to the efficiency of industry and life by providing information in real time.
a short period of time. New findings expected from unprecedented analysis.
IoT
Big Data and AI
TOD
Disaster-Resilient Urban development
Eco-Cities
Automated Driving
Biometric Authenticatio
Face
Fingerprint
Palmprint
Voice
Iris
Ear
Contributing to driver shortage, securing local public transportation and MaaS. Eliminating human error and ensuring safety
Authentication by fingerprint and pupil is already widely used. New services introduction, including automatic bus

❖ Through cooperation between actors, it is possible to make cities smart at several levels:

- An intelligence of tools through innovation and digital;
- An intelligence of the organization of spaces thanks to the engineering of urban planning and the emergence of new functionalities in cities;
- The intelligence of the citizen, who has access to relevant information and can thus make better decisions, creating a virtuous circle.

The smart city is therefore a community which understands its challenges and which is proactive in developing solutions to these issues

Clarification of the topic: How does it work ?

✓ Efficient use of energy and realizing energy conservation and zero emissions

Concept: Encouraging the efficient use of energy and reducing greenhouse gas emissions

Issues of Urban Cities and Goals

Issues

- Efficient use of energy.
- Developing urban infrastructure
- Increasing greenhouse gas emissions.
- Stable use of renewable energy.

Goals

- Reducing CO2 emissions.
- Reducing greenhouse gas (GHG) emissions.
- Realizing local production and local consumption of renewable energy.

Japan's Solutions

- Local production and local consumption of energy with a focus on renewable energy.
- Industrialization of local resources, Shikaoi Town and Obihiro City (hydrogen, which does not generate CO2, is produced from biogas obtained from livestock manure and used for fuel cell vehicles, aquaculture).
- Establishing autonomous distributed energy system.
- Dispersing electricity peaks according to demand response by using Community Energy Management System (***CEMS***).
- Establishing a locally produced and locally consumed energy system that utilizes CEMS, Home Energy Management System (HEMS), Building Energy Management System (BEMS), Electric Vehicle (EV).

✓ Maximizing the capacity of transportation and logistics infrastructure

Concept: Improving convenience for citizens and promoting industry through the provision of new mobility services

Issues

- Ensuring healthy life expectancy for residents.
- Revitalizing the local economy through increased human flow.
- Improving the attractiveness of cities.

Goals

- Improving the safety and convenience of residents' mobility. Improving the quality of life for vulnerable people in particular with limited transportation mobility by encouraging them to go out through increased opportunity to exercise and communicate.
- Easing congestion by making traffic more efficient.
- Creating sustainable cities where diverse generations live.

Japan's Solutions

- Smart mobility. Developing car sharing and bicycle sharing. Providing on-demand last-one-mile mobility.
- Introduction of automated driving public transportation.
- Improving traffic accessibility using face authentication system
- Smart planning for urban development using data.
- Incentivizing residents to go out through the introduction of applications.
- Building a MaaS model that solves local issues by linking transportation methods with non-transportation services such as retail and tourism, at destinations.

✓ Realizing a world's safest and securest society (disaster preparedness and crime prevention)

Concept: Real-time notification of emergencies and hazards to residents in wide areas. Promptly providing security and safety

Issues

- Deterring terrorism and crime while protecting individual privacy.
- Responding to the increase in disasters associated with climate change.

Goals

- Crime control.
- Improving urban risk assessment.
- Prompt and effective disaster prevention and reduction.
- Increasing the rate of attracting conferences, events, and regional business bases.

Japan Can Offer Various Solutions

- Detection, prediction, and advanced analytical skills to grasp on-the-spot situation. thereby reducing response time.
- Personal identification while ensuring personal privacy.
- End-to-end connectivity of ICT resources for rapid deployment and configuration optimization.
- Urban development using big data

Remarks

○ Japan is a safe country with one of the lowest crime rates among developed nations (ranked 3rd to 7th in recent years according to a United Nations survey).

○ In addition, despite the fact that the United Nations disaster risk assessment report identified Japan as an area at high risk of all kinds of disasters, Japan was successfully able to control flood damage.

✓ Infectious disease control and public health that will set a new world standard

Concept: Improving public health through infrastructure development and preventing the spread of infectious diseases

Issues

- Improving public health thereby reducing and eliminating diseases and infectious diseases.
- Preventing the elderly, pregnant women and nursing mothers, and children, in particular from physically contacting with an unspecified number of people at the time of an outbreak of an infectious disease.

Goals

- Appropriate waste management through basic urban infrastructure development.
- Ensuring the health of vulnerable residents

Japan's Solutions

- Urban development with basic urban infrastructure including sewerage and decentralized wastewater treatment system
- Appropriate waste management through implementing Waste to Energy facility.
- A telemedicine system that utilizes mobile and cloud technologies.

Remarks

- The volume of waste can be reduced by almost one-tenth by Waste to Energy process.
- mobile measurement and monitoring device can be used to grasp the health status of mothers and children.

✓ **Expanding access to education and improving the quality of education**

Concept: Providing “inclusive and high-quality education that leaves no one left behind” by using ICT.

Issues

- Further improving the quality of school education.
- Eliminating regional disparities due to regional characteristics (remote islands and mountainous regions).
- Quality assurance and globalization in higher education.
- Ensuring learning opportunities in the event that schools are temporarily closed due to a disaster or the spread of an infectious disease.

Goals

- Developing human resources capable of responding to innovation through the use of IoT and AI.
- Improving the quality of detailed education and reducing the workload of teachers and staff.
- Ensuring learning opportunities in an emergency situation.

Japan’s Solutions

- Drastic improvement of school ICT environment.
- Promoting the use of ICT in education.
- Improving efficiency of school affairs by using a school affairs support system.
- COIL (Collaborative Online Implementing Collaborative Online International Learning.
- Implementing distance and online education.

✓ **Asset management and ensuring long-life and reliable infrastructure**

Concept: Reducing the lifecycle cost of infrastructure by utilizing data based on reality.

Issues

- Robust maintenance of basic infrastructure that supports people’s daily lives.
- Addressing the unpredictability and difficulty of predicting the scale and location of infrastructure where an accident may occur.

Goals

- Maintaining infrastructure that can provide safety and security for residents while reducing the costs and risks of basic infrastructure management.
- Realizing planned basic infrastructure investments.
- Providing a safe and secure environment for residents including prompt recovery from a disaster by utilizing data.

Japan’s Solutions

- Grasping and managing road surface conditions using data from accelerometers and vehicle-mounted cameras.
- Prioritized repair of heavily trafficked roads by using a combination of deterioration detection data based on AI-processed image data and human flow analysis data.
- Using the difference of three-dimensional point group data to grasp changes over time for the maintenance and management of roads and rivers.
- Highly accurate damage/leakage prediction using AI/machine learning for water pipes (Note: Tests are also being conducted on gas pipes).
- Calculation of the amount of accident risk taking into account the surrounding circumstances.

Specific Smart Cities project in Japan

Kita-Kyushu Smart Community Project: from the city symbolizing industrial pollution to the example of the green city

Kitakyushu's smart community relies primarily on the implementation of energy management **systems and focuses primarily** on hydrogen, with homes connected to a hydrogen plant through pipelines. These homes generate electricity using their own fuel cells, sometimes stored in the form of hydrogen. The use of such innovations also aims to transform electricity consumers into consumers and producers ("prosumers") by installing photovoltaic panels and other systems and to implement autonomous demand management so that individuals and businesses private sector use traditional energy and the introduction of dynamic pricing and incentive programs.

Kyoto Keihanna Eco City

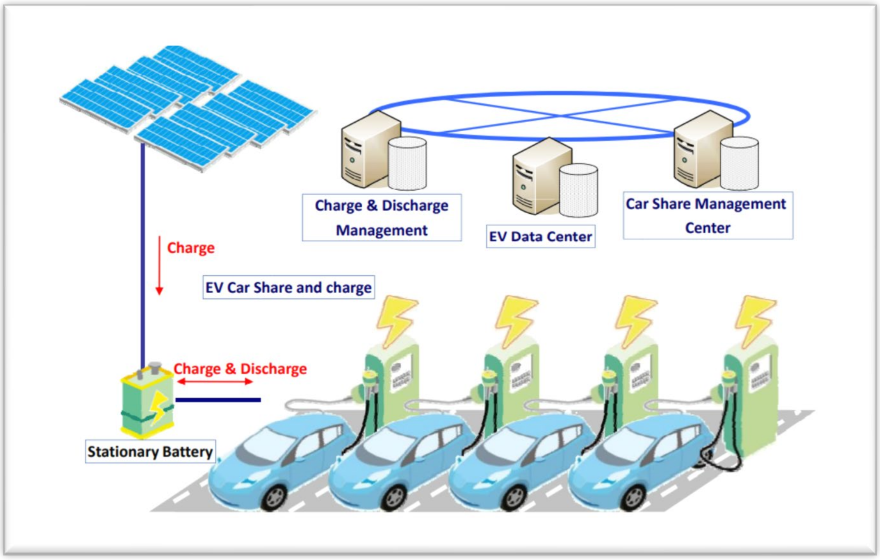
The project studies the **optimization of energy supply and demand** on a global scale in order to reduce energy consumption and greenhouse gas emissions without affecting the quality of life or the comfort of residents.

Yokohama, a model of smart city

This flagship project is based on the introduction of renewable energies, energy management of households, buildings and local communities and next generation transportation systems. Its initial objective was to develop a Smart city model by bringing together citizens, private companies (Accenture, Tokyo Gas, Toshiba, Nissan Motor, Panasonic, Meidensha, TEPCO) and the municipality via various large-scale experiments. on **energy management and demand response.**

Vertical farming in Kyoto

Vertical farming is the practice of growing crops in vertically stacked layers.[1] It often incorporates controlled-environment agriculture, which aims to optimize plant growth, and soilless farming techniques

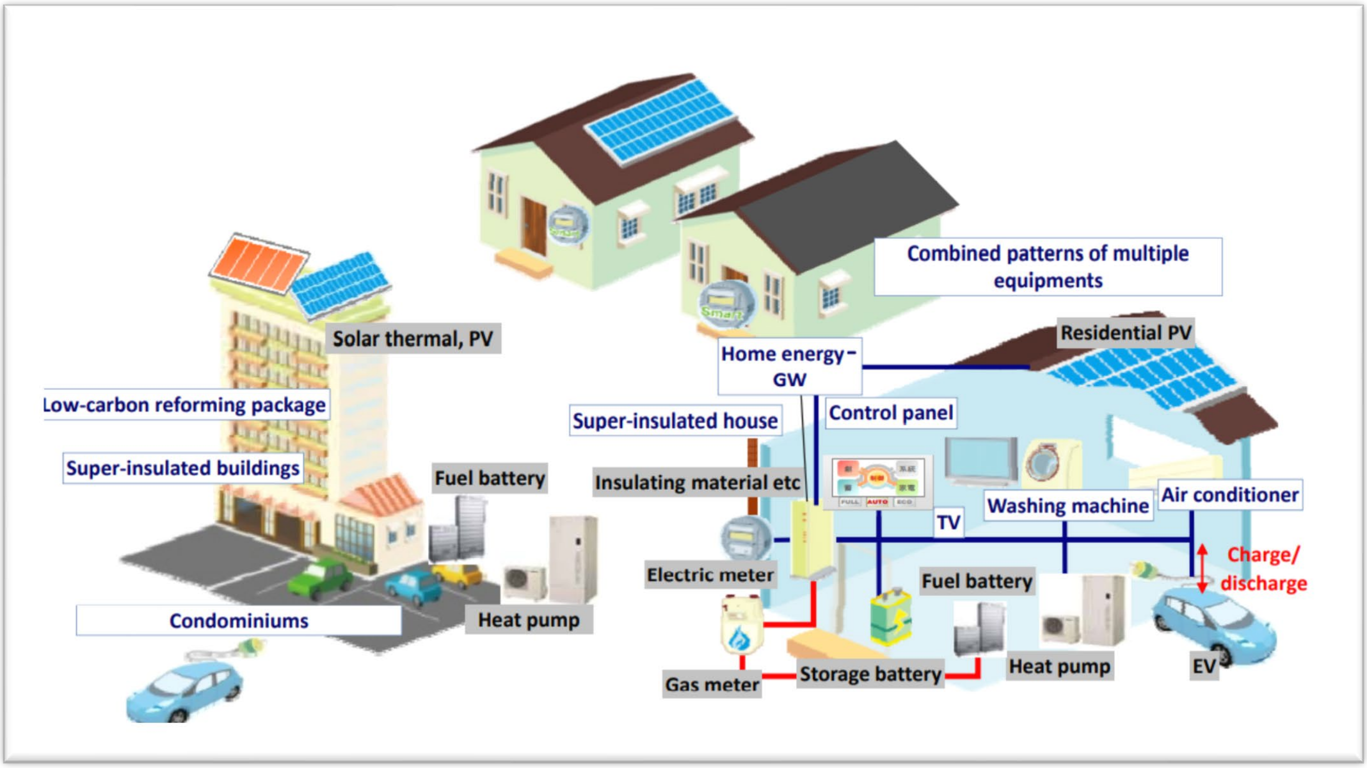


Energy Management with Charge and Discharge Enabled EV

Increase usage of solar power and lower well to wheel EV CO2 footprint by developing Charge and Discharge enabled EVs that can be leveraged as clean energy storage in the three areas

Home Energy Management System

Introduces combined patterns of multiple PV and energy saving equipments to houses and buildings examines to **minimize the costs** by combining with reforming and expansion of efficiency by insulating materials



Part 2: Tsunami-Resistant construction

Introduction: Civil engineering and Tsunami

Architects and engineers can design buildings that will stand tall during even the most violent earthquakes. However, a tsunami. a series of undulations in a body of water that is often caused by an earthquake, has the power to wash away entire villages. Then, they try to optimize solutions the construction of those construction to ignore any risks.

Understanding the problem: What Causes the Damage?

Tsunamis are usually generated by powerful earthquakes underneath large bodies of water. The seismic event creates a subsurface wave that is more complex than when the wind simply blows the water's surface. The wave can travel hundreds of miles an hour until it reaches shallow water and a shoreline. The Japanese word for harbor is *tsu* and *nami* means wave. Because Japan is heavily populated, surrounded by water, and in an area of great seismic activity, tsunamis are often associated with this Asian country. They occur, however, all over the world.

Structures tend to be destroyed by tsunamis because of five general causes.

- ✓ **First** is the force of the water and high-velocity water flow. Stationary objects (like houses) in the path of the wave will resist the force, and, depending how the structure is constructed, the water will go through or around it.
- ✓ **Second**, the tidal wave will be dirty, and the impact of debris carried by the forceful water may be what destroys a wall, roof, or piling. Third, this floating debris can be on fire, which is then spread among combustible materials.
- ✓ **Fourth**, the tsunami rushing onto land and then retreating back to the sea creates unexpected erosion and scour of foundations. Whereas erosion is the general wearing away of the ground surface, scour is more localized—the type of wearing away you see around piers and piles as water flows around stationary objects. Both erosion and scour compromise a structure's foundation.
- ✓ **The fifth** cause of damage is from the waves' wind forces.

Strategies for optimization of the Tsunami-Resistant Construction

Shrewd engineering combined with a swift, efficient warning system can save thousands of lives. Engineers and other experts suggest these strategies for tsunami-resistant construction:

1. Build structures with **reinforced concrete** instead of wood, even though wood construction is more resilient to earthquakes. Reinforced concrete or steel-frame structures are recommended for vertical evacuation structures.
2. Mitigate resistance. Design structures to let the water flow through. Build multi-story structures, with the first floor being open (or on stilts) or breakaway so the major force of water can move through. Rising water will do less damage if it can flow underneath the structure.
3. Construct **deep foundations**, braced at the footings. A tsunami's force can turn an otherwise solid, concrete building completely on its side, substantive deep foundations can overcome that.
4. Design with **redundancy**, so that the structure can experience partial failure without progressive collapse.
5. As much as possible**, leave vegetation and reefs intact**. They won't stop tsunami waves, but they can act as a natural buffer and slow them down.
6. Orient the building at an **angle to the shoreline**. Walls that directly face the ocean will suffer more damage.
7. Use **continuous steel** framing strong enough to resist hurricane-force winds.
8. Design **structural connectors** that can absorb stress.

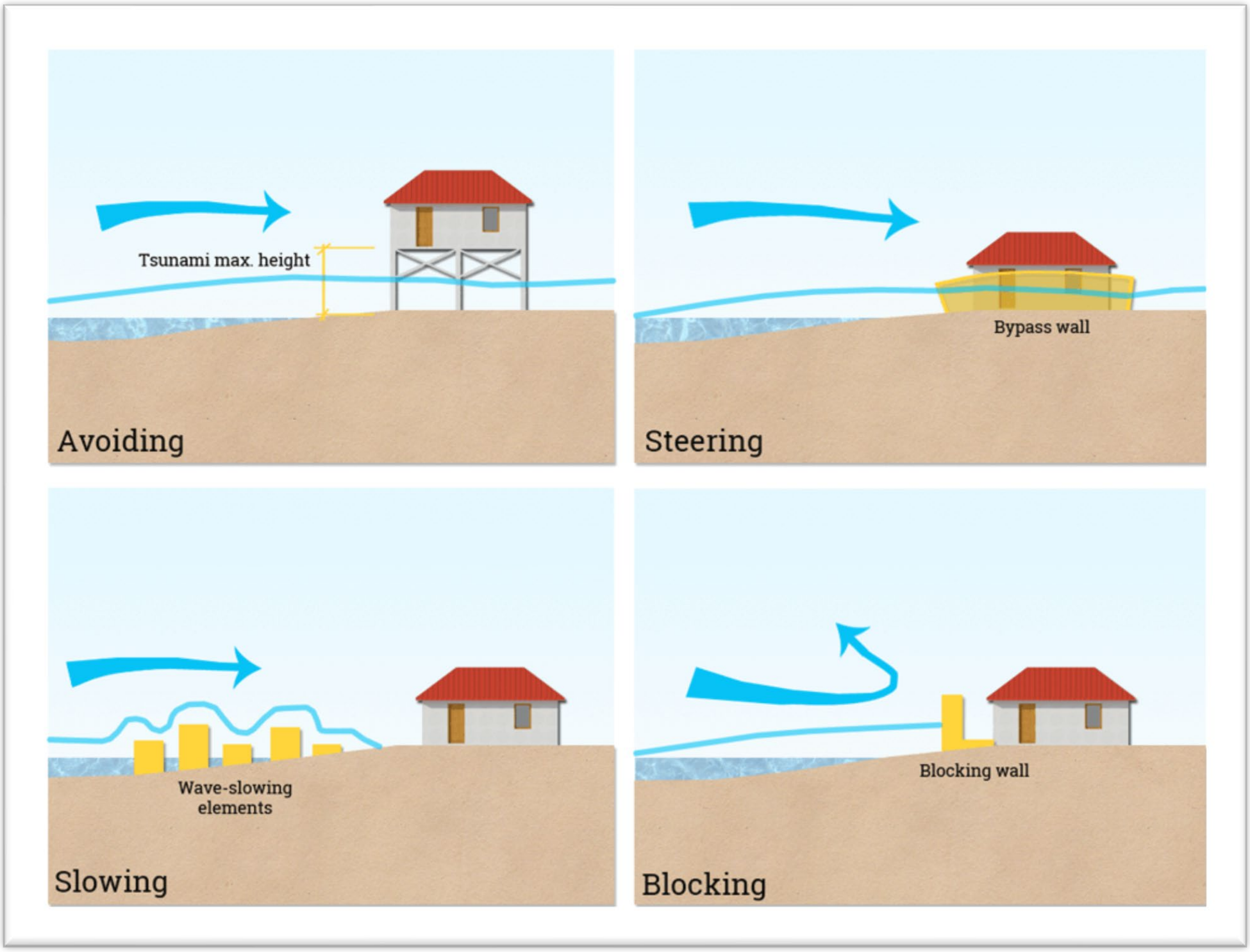
The japan building ‘ Great wall ‘ Against Tsunami

Since the terrible tsunami of 2011 that triggered the Fukushima disaster, Japan has intensified the construction and reconstruction of protection on the most affected parts of its coastline. With the help of a gigantic budget, the country wants to protect itself more effectively against possible future devastating tsunamis. Since then, the Japanese government has invested the equivalent of ten billion euros to build (and rebuild) the ramparts of the coastal regions. Soon, 430 km of continuous dikes should be completed in the three departments most affected in 2011, namely Fukushima, Iwate and Miyagi. In Taro, the walls now rise to a height of around 15m and again cover over 2km of coastline.

OPTIMIZATION STRATEGIES TO REDUCE RISKS IN DANGEROUS AREAS

When building a house in an area at risk of tsunamis, one of four main strategies can be adopted to mitigate the destructive power of tsunami waves.

- ✓ **Avoiding:** Elevate buildings using stilts or podium above the maximum expected wave height in the area.
- ✓ **Slowing:** Create friction: forest, slopes, ditches, berms, coastal mangroves between the coast and the house lessen the wave power.
- ✓ **Steering:** Guide the tsunami wave by strategically positioning angled walls and ditches.
- ✓ **Blocking:** Stop the force of waves with hardened structures: seawalls, rigid constructions, and berms. The method has an undesirable side effect: it can amplify the wave height in reflection or alter the destructive energy to other areas.



Part 3: Reflexions and personal view

Are there really any prospects for a broadening of this subject?

For **smart cities**, it will be an asset to make any routine and secondary task automated by the use of robots, digital systems and the automation of systems. This is of course while respecting the values of the human being and without harming his living conditions. Moreover, it is preferable to also focus on young people, offering them a better education strategy, using more sophisticated education techniques.

Anti-Tsunami construction can be improved by visualizing building materials that adapt to heavy sea shock and weather conditions.

Application in Morocco

In my personal view, I see that Morocco is fertile ground for the involvement of smart cities. They have all the means necessary for the realization of such a project. **We just need to build a generation that adapts to radical changes.** This will completely change the lives of all participants. Moreover, there are quite a few future projects in the 2050 horizon for the realization of such a project: as is the case for Casa blanca and Tagier.

For the Anti-Tsunami Construction as these projects will be useful since there are many Moroccan regions that risk encountering this kind of natural disaster (Casa blanca - Dakhla).

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